Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.1 Summarize the basic properties of light (including brightness and colors).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the properties of light before this grade level. In 8th grade (8-6.8), students will compare the wavelength and energy of waves in various parts of the electromagnetic spectrum (including visible light, infrared, and ultraviolet radiation).

It is essential for students to know the basic properties of light, including brightness, colors, and being visible.

Brightness
- The intensity of light or *brightness* of light is related to the amount of light being seen.
- The closer the source of the light is, the greater the intensity or degree of brightness.
- The greater the distance the source of the light is, the lesser the intensity or brightness.

Colors
- Light, or "white light", is made up of all colors of light mixed together.
- If white light is passed through a *prism*, it can be separated into light of different *colors.*
- The colors are red, orange, yellow, green, blue, and violet.
- These are the colors seen in a rainbow.

NOTE TO TEACHER: Some textbooks include indigo (a part of the blue range) in the spectrum of colors.

Visible
- In order for an object to be visible, it must either give off its own light (be a source of light) or it must reflect light.
- The Sun, a candle flame, or a flashlight gives off visible light.
- The Moon and many objects around us reflect light in order to be seen.

It is not essential for students to know about wavelengths or frequencies of light associated with colors.

Assessment Guidelines:
The objective of this indicator is to *summarize* the basic properties of light; therefore, the primary focus of assessment should be to generalize the main points about basic properties of brightness and colors of light. However, appropriate assessments should also require students to *compare* objects of different brightness; *interpret* a diagram containing objects giving off light at different distances; *identify* colors that are part of white light; or *recognize* objects of different colors and brightness.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4.5.2 Illustrate the fact that light, as a form of energy, is made up of many different colors.

Taxonomy level: 2.2-B Understand Conceptual Knowledge

Previous/Future knowledge: In 1st grade (1-2.1), students recalled the basic needs of plants (including light) for energy and growth. Students have not been introduced to the concept of different forms of energy before this grade level. In 6th grade (6-5.1, 2), students will identify sources and properties of heat and solar energy. In 8th grade, students will recall that waves transmit energy (8-6.1) and will explain how the absorption and reflection of light waves by various materials result in the human perception of color (8-6.7).

It is essential for students to know that light is a form of energy and is made of many colors.

Energy

- *Energy* is the ability to make something move, happen, or change. -

Colors

- The different *colors* of light are revealed when white light is passed through a *prism* and separated into the different colors of the rainbow, called the *spectrum*.
- These colors are related to the different amounts of energy in white light.
- Each color represents a different amount of energy.

It is not essential for students to know the order of these colors in the rainbow or which colors are higher or lower in energy. They also do not need to know how projected colors mix to form different colors or white light, nor do they need to know which color pigments mix to form which different colors.

Assessment Guidelines:

The objective of this indicator is to *illustrate* the fact that light is made up of many different colors and that it is a form of energy; therefore, the primary focus of assessment should be to give or use illustrations as pictures, diagrams, or words that show light is made up of many different colors. However, appropriate assessments should also require students to *interpret* a diagram of white light going through a prism with different colors coming out of it; *recognize* examples of light being made up of many different colors; or *identify* light as a form of energy.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.3 Summarize how light travels and explain what happens when it strikes an object (including reflection, refraction, and absorption).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concept of light and how it travels in previous grades. They will study reflection, refraction, and absorption as behaviors of waves in the 8th grade (8-6.4).

It is essential for students to know that light travels in a straight line away from the light source. It can travel through transparent material (4-5.4) and even through empty space. The way that light reacts when it strikes an object varies with the object.

Reflection
- When light is *reflected,* it bounces back from a surface.
- Reflection allows objects to be seen that do not produce their own light.
- When light strikes an object, some of the light reflects off of it and can be detected by eyes.
- When light strikes a smooth, shiny object, for example a mirror or a pool of water, it is reflected so that a reflection can be seen that looks very similar to the object seen with light reflected directly from it.
- The color of the light that is reflected from an object is the color that the object appears. For example, an object that reflects only red light will appear red.

Refraction
- When light is refracted it passes from one type of transparent material to another, and changes direction. For example, when light travels through a magnifying glass, it changes direction, and we see a larger, magnified view of the object.
- When a straw is viewed in water, light passes from the water to the air causing the path of the light to bend. When the light bends, the straw appears distorted (bent or broken)

Absorption
- When light is *absorbed* it does not pass through or reflect from a material. It remains in the material as another form of energy.
- The colors of objects are determined by the light that is not absorbed but is reflected by the objects.
- All other colors of light striking the object are absorbed by the object.
- A red object, for example, reflects red colors of light and absorbs all other colors.

It is not essential for students to know about angles of reflection or refraction or the mixing of pigments or light to form various colors.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

Assessment Guidelines:

The objective of this indicator is to *summarize* how light travels and also to *explain* what happens when light strikes an object; therefore, the primary focus of assessment should be to generalize major points about the way light travels and to construct a cause-and-effect model of what happens when light strikes various objects. However, appropriate assessments should also require students to *interpret* diagrams of light traveling and of light striking different objects; *compare* light striking different objects as to the behaviors of reflection, refraction, and absorption; or *recognize* light traveling in a straight line and what happens when it strikes various objects.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.4 Compare how light behaves when it strikes transparent, translucent, and opaque materials.

Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concept of light and how it behaves when it strikes transparent, translucent, and opaque materials in previous grades. They will further develop the concept of light traveling in waves in the 8th grade (8-6.4).

It is essential for students to know that light behaves differently when it strikes different types of materials.

Transparent

- A *transparent* material allows light to pass through it because it is not absorbed or reflected.
- Objects can be seen clearly when viewed through transparent materials.
- Air, glass, and water are examples of materials that are *transparent*.

Translucent

- A *translucent* material scatters or absorbs some of the light that strikes it and allows some of the light to pass through it.
- Objects appear as blurry shapes when viewed through translucent materials.
- Waxed paper and frosted glass are examples of materials that are *translucent*.

Opaque

- An *opaque* material does not allow light to pass through, light is either reflected from or absorbed by an opaque material.
- Wood, metals, and thick paper are examples of materials that are *opaque*.

It is not essential for students to know about the interaction of light waves with materials to make them transparent, translucent, or opaque.

Assessment Guidelines:

The objective of this indicator is to *compare* how light behaves when is strikes various materials; therefore, the primary focus of assessment should be to detect likes and differences in the behavior of light when it strikes one type of material versus another or to match types of materials to the behavior of light when it strikes them. However, appropriate assessments should also require students to *interpret* a diagram or picture containing various objects and how light behaves when striking them; *classify* various types of materials depending on how light behaves on striking them; or *exemplify* materials that are transparent, translucent, and opaque.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.5 Explain how electricity, as a form of energy, can be transformed into other forms of energy (including light, heat, and sound).
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concept of electricity and energy changing from one form to another including electricity, light, heat, and sound in previous grades. In 6th grade (6-5.1, 2), they will further develop the concepts of transformation and conservation of energy.

It is essential for students to know that electricity is a form of energy that can be cause change and be changed into other forms of energy. For example:

Light
- Electrical energy can be changed to *light energy* with light bulbs in lamps, televisions, and computer monitors.

Heat
- Electrical energy can be changed to *heat energy* in stoves, toasters, and ovens.

Sound
- Electrical energy can be changed to *sound energy* with radios and televisions.

It is not essential for students to know the reasons why the electrical energy is being changed, only that it is being changed by identifying *devices* that do change the energy to other forms.

Assessment Guidelines:
The objective of this indicator is to *explain* how electrical energy can be changed to other forms of energy, for example, light, heat, and sound; therefore, the primary focus of assessment should be to construct a cause-and-effect model showing devices that change electrical energy to light, heat, or sound. However, appropriate assessments should also require students to *interpret* a diagram of or *illustrate* various electrical devices showing energy transformations; *compare* electrical devices as to the types of energy transformations that take place; or *recognize* an electrical device that transforms electrical energy into light or heat or sound.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.6 Summarize the function of the components of complete circuits (including wire, switch, battery, and light bulb).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concept of electricity and circuits in previous grades. They will further develop the concepts circuits as they study electric motors, generators and electromagnets in 6th grade (6-5.3) and circuit diagrams in high school Physical Science (PS-6.8).

It is essential for students to know the components of a complete *circuit* (a closed path through which electricity flows) and their symbols including the wire, switch, battery, and light bulb (see also 4-5.7). The components of complete circuits with their symbols in parentheses are listed below with their functions:

- The *wire* ( ) conducts the electric *current* (the flow of electricity)
- The *switch* () completes the circuit and allows current to flow if closed and stops the current if open
- The *battery* () pushes the electric current around the circuit
- The *light bulb* () is the object in the circuit that changes electrical energy to light energy

It is not essential for students to know how these components function or what would happen if more components were added to the circuit.

Assessment Guidelines:
The objective of this indicator is to *summarize* the function of the components of a complete electrical circuit; therefore, the primary focus of assessment should be to generalize major points about characteristics and functions of the circuit components. However, appropriate assessments should also require students to *interpret* a diagram of a circuit with the symbols of the components; *compare* components of the circuit; *recognize* components of the circuit and their symbols and what they do in the circuit; or *infer* what would happen if various components were missing or if the switch were open or closed in the circuit.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.7 Illustrate the path of electric current in series and parallel circuits.
Taxonomy level: 2.2-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concept of electricity and types of circuits in previous grades. They will further develop the concepts of circuits as they study electric motors, generators and electromagnets in 6th grade (6-5.3) and the functioning of simple parallel and series circuits in high school Physical Science (PS-6.9).

It is essential for students to know the path of the electric current in electric circuits as follows:

Series circuit

- In a *series circuit*, electric current goes through each device in the circuit in one sequential, complete path from the source of the current.
  - A diagram of a *series circuit* has one path for the electric current to flow through and has symbols for at least one battery, a wire, and one or more devices that change electrical energy to another form of energy for example light (light bulbs).
  - If one light bulb in a series goes out, all the other light bulbs in the circuit go out too because the circuit is no longer complete.

Parallel circuit

- In a *parallel circuit*, however, the current branches into several loops and has more than one path through which the electric current flows.
  - A diagram of a parallel circuit shows more than one path through which the electric current flows and has symbols for at least one battery and several wires in more than one loop, branch, or path. Each path contains at least one device (for example a light bulb) that changes electrical energy to another form of energy.
  - If a light bulb goes out in one of the loops or paths of a parallel circuit, the lights in the other loops stay on because the electric current can flow in more than one path.

It is not essential for students to explain why the brightness of the bulbs gets dimmer as bulbs are added in a series circuit, or why the brightness stays about the same with several bulbs in a parallel circuit. Nor do they have to explain what happens when more batteries are added to series versus parallel circuits.

Assessment Guidelines:
The objective of this indicator is to *illustrate* the path of electric current in series and parallel circuits; therefore, the primary focus of assessment should be to give or use illustrations as examples of series and parallel circuits with models. However, appropriate assessments should also require students to *interpret* a diagram of series and parallel circuits; *compare* examples of series and parallel circuits; *compare* series and parallel circuits; or *recognize* series and parallel circuits.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.8 Classify materials as either conductors or insulators of electricity.
Taxonomy level: 2.3-B Understand Conceptual Knowledge

Previous/Future knowledge: In 3rd grade (3-4.3), students explained how heat moves easily from one object to another through direct contact in some materials (called conductors) and not so easily through other materials (called insulators). Students will be introduced to the concept of electricity and materials that conduct or insulate electricity for the first time at this grade level.

It is essential for students to classify materials as conductors or insulators of electricity based on whether they allow electric current to flow through the circuit or not as described below:

Conductors
- *Conductors* allow electric current to flow through them in an electric circuit.
- If a bulb stays lit when an object is added to an electric circuit, the material is conducting the current through the circuit, and it is a conductor.
- Metals are conductors of electricity.

Insulators
- *Insulators* do not allow electric current to flow through them in an electric circuit.
- If a bulb does not stay lit when an object is added to an electric circuit, the material does not conduct current, and it is an insulator.
- Plastics and wooden materials are examples of insulators.

It is not essential for students to explain why some materials conduct electricity and others do not.

Assessment Guidelines:
The objective of this indicator is to *classify* materials as conductors or insulators of electricity; therefore, the primary focus of assessment should be to group materials as insulators or conductors based on whether they allow electric current to flow through them or not. However, appropriate assessments should also require students to *interpret* a diagram of a series circuit with an object in the circuit as being a conductor if the light is on and an insulator if the light is not; *exemplify* materials that are conductors or insulators; or *recognize* an object as a conductor or insulator based on what it is made of.

4-5.9 Summarize the properties of magnets and electromagnets (including polarity, attraction/repulsion, and strength).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have been introduced to properties of magnets in kindergarten (K-5.1) and in 2nd grade (2-5) when they observe magnetism, explain the poles of magnets, compare the effects of magnets, and identify everyday uses of magnets. Students have not been introduced to the concepts of polarity and magnetic strength in previous grades. They will further develop the concept of electromagnets in 6th grade (6-5.3) when students will explain how magnetism and electricity are interrelated in electromagnets, generators, and simple electrical motors.

It is essential for students to know that an *electromagnet* becomes a magnet when an electric current passes through an insulated wire that is wrapped around an iron core (nail). The properties of magnets and electromagnets can be summarized as follows:

Polarity
- Magnets and electromagnets have areas on their ends (if bar or horseshoe magnets) or on their tops and bottoms (if ceramic, plastic, or "donut" magnets) that are called *poles*.
- The magnetic pull or attraction is strongest at these poles. Every magnet has a *North* pole and a *South* pole.
- The poles of magnets affect each other in the following ways:
  - *Like poles*
    - If the North pole of one magnet and the North pole of another magnet are brought close to each other, they will move away from each other or repel.
    - The same thing happens if the South pole of one magnet and the South pole of another magnet are brought close to each other.
    - *Like poles repel each other*.
  - *Unlike poles*
    - If the North pole of one magnet and the South pole of another magnet are brought close to each other, they will move toward each other or attract.
    - *Unlike poles attract each other*.

Attraction
- Magnets and electromagnets *attract* or tend to move toward each other (if unlike poles are near each other) and certain types of metals (mainly iron or steel).
- When iron nails or steel paper clips are held near a magnet, they will move toward or be attracted to the magnet.

Repulsion
- Magnets and electromagnets can *repel* or move away from each other if their like poles (North-North or South-South) are brought near each other.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

Strength

- The attractive *strength* of a magnet or electromagnet is greatest at its poles.
- Some magnets have a greater attraction for magnetic materials than others.
- The size of the magnetic attraction of a magnet or electromagnet can be measured by counting the number of objects, for example paper clips that a magnet can pick up.

It is not essential for students to draw lines of force or magnetic field diagrams for magnets, although a demonstration might be appropriate so that students can visualize magnetic force. Students do not need to know how to induce magnetism in objects.

Assessment Guidelines:
The objective of this indicator is to *summarize* properties of magnets and electromagnets; therefore, the primary focus of assessment should be to generalize the major characteristics of magnets and electromagnets. However, appropriate assessments should also require students to *interpret* a diagram of magnets with opposite or like poles together to determine which would have attractive forces and which would have repulsive forces; *identify* locations on a bar magnet for where the greatest magnetic strength would be; or *infer* the poles of two magnets as being alike or different if the forces were attractive or repulsive.

Properties of Light and Electricity

4-5 The student will demonstrate an understanding of the properties of light and electricity. (Physical Science)

4-5.10 Summarize the factors that affect the strength of an electromagnet.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concept of electromagnets in previous grades. Student will further develop the concept of electromagnets in 6th grade associated with electric motors and generators (6-5.3).

It is essential for students to know the factors that affect the strength of an electromagnet are:

Number of coils of wire
- By increasing the number of coils of insulated wire around an iron core (such as a bolt or nail), the strength of the electromagnet can be increased.

Number/voltage of batteries
- By using a battery with a greater voltage or adding more batteries (in series) to the electric circuit, the strength of the electromagnet can be increased.

Properties of the core
- An iron core will produce the strongest magnet. By increasing the diameter of the core, the strength of the electromagnet can be increased.

It is not essential for students to explain why these factors affect the strength of the electromagnet or why the electromagnet is magnetic. Students do not need to make or explain motors and generators.

Assessment Guidelines:
The objective of this indicator is to *summarize* the factors that affect the strength of an electromagnet; therefore, the primary focus of assessment should be to generalize the major factors giving the electromagnet strength, for example, number of coils of wire, voltage of the battery, and the diameter of the iron core. However, appropriate assessments should also require students to *interpret* diagrams of electromagnets to determine which would be the strongest based on factors described above; *compare* electromagnets to determine which would be the strongest or weakest; or *recognize* which electromagnet would be strongest based on factors described above (only one at a time).